Learners' Needs Satisfaction, Classroom Climate, and Situational Motivations: Evaluating Self-Determination Theory in an Engineering Context

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***Abstract*—This work-in-progress study examines connections among classroom climate, psychological needs satisfaction, and motivations in a college course setting. According to self-determination theory (SDT), positive forms of motivation arise when people experience a sense of competence, relatedness, and autonomy. In learning settings, these three basic psychological needs are satisfied when students feel a sense of efficacy and mastery; a supportive connection to others; and choice and control. Research illustrates that instructors play an important role in creating environments that support these three needs through their pedagogical choices, interactive style, and classroom culture and climate setting. In this study, we explore relationships among students' needs satisfaction, perceptions of the learning climate, and situational motivations. Participants in the study are first-year undergraduate engineering students enrolled in a technical course that uses non-traditional pedagogies to integrate math, science, and engineering. Student responses to the Situational Motivation Scale, Basic Psychological Needs Satisfaction scale, and Learning Climate Questionnaire are analyzed using descriptive statistics, t-tests, and bivariate correlations. Consistent with SDT predictions, our findings show that students' needs satisfaction and positive evaluations of the learning climate correlate positively to autonomous motivations. We also observe that students' positive motivations are not entirely temporally stable. Over a one-week period in a course project, students report a significant drop in positive motivations followed by a quick recovery. Using information on the course context and assignments, we offer possible explanations for the temporal shifts in motivations. Our preliminary findings highlight important connections between motivations and course variables that instructors may influence through their choice of learning activities and pedagogies.**

Keywords—motivation, basic needs, self-determination theory, autonomy, competence, relatedness, classroom climate

I. Introduction and Research Background

Research shows that the healthiest, most enjoyable, and most effective learning processes rely on the triggering of positive learning motivations [1]. When students are able to find value, interest, and enjoyment in learning activities, they engage more deeply, self-regulate more effectively, persist longer, and perform better [1], [2], [3], [4], [5], [6]. Conversely, when learners are driven by extrinsic pressure or unsure why they are engaged, their learning is more superficial, their persistence and performance are lower, and they may feel boredom, anxiety, or shame [1], [7], [8], [9]. Positive learner motivations do not appear out of nowhere, however; motivations are directly shaped by learners' assessments of their needs and goals, appraisals of their learning activities, and evaluations of their social and environmental conditions [10]. That is, the *learning situation* influences students' motivations. This study aims to shed light on the connections between college students' situational motivations and their perceptions of their course environment.

A. Self-Determination Theory for Motivation

This investigation takes a Self-Determination Theory (SDT) based approach to understanding motivations in the classroom [1], [10], [11]. SDT is a needs-based theory that argues that individuals will adopt internalized or "autonomous" motivations when three basic psychological needs are satisfied: *competence*, a sense of mastery or self-efficacy; *relatedness*, a sense of positive and supportive connections to others; and *autonomy*, a sense of choice and control [11]. When these needs are not satisfied, SDT suggests that learners will adopt more externalized or "controlled" motivations.

SDT maps controlled and autonomous motivations along the self-determination continuum (Fig. 1), which ranges from external (controlled) motivations on the left, to internal (autonomous) motivations on the right [10]. Controlled motivations include *amotivation,* a condition that occurs when learners find no value in the learning activity and expect no desirable outcome, and *external regulation*, a drive baesd on external rewards, punishment avoidance, and a sense of compliance. Autonomous motivations include *identified regulation*, a partially internalized drive based on a sense of value or importance, and *intrinsic motivation*, a state described by inherent interest, enjoyment, satisfaction, and passion. Research shows that internalized motivations generally bear positive relationships to desirable outcomes and healthier

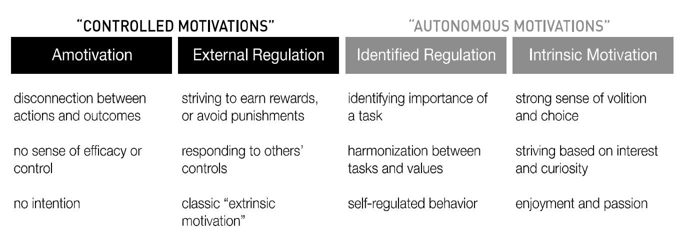

Fig. 1. Simplified version of the self-determination continuum for motivation, adapted from [1].

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engagement in learning, while externalized motivations generally do not [3], [12], [13], [14], [15].

B. Situational Motivations

To distinguish between short-term and long-term motivational responses, SDT researchers use the Hierarchal Model [16], [17], [18], which describes motivations at three categories of generality: global, contextual, and situational (Fig. 2). This study focuses on the *situational level*, which describes motivational responses to a particular activity, such as a course assignment. Contextual motivations are more abstract, and can describe a person's perceived relationship to domains such as "school," "sports," or "engineering." Global levels are further abstracted and contain motivational orientations that people perceive as a part of their personal identity. Research shows that all levels of motivation can change over time, and that the three levels interact in a reciprocal manner [18], [19]. In the top-down direction, the way an individual approaches school and learning in general can affect the way she approaches new learning tasks or environments. In the bottom-up direction, specific course activities will, over time, influence a student's general feelings toward learning. Importantly, these interactions may operate both for better and for worse.

C. Effects of Classroom Climate on Motivations

The conditions of the learning environment matter to motivation. Empirical research shows that instructors can shape learning activities and classroom climate in powerful ways through their choice of goals and pedagogies, communicative and interactive styles, and feedback and assessment approaches [15], [20], [21], [22], [23], [24]. Instructors may adopt directly controlling strategies and behaviors that undermine basic needs and self-determined motivations, or they may choose to build a classroom climate that supports students' sense of efficacy and success, supportive connections to others, and choice and control [25], [26]. Instructors' choices about course design and classroom climate, in turn, have a direct impact on learners' motivations.

Since situational motivations are near-term responses shaped by students' reactions to activities and environments, one might anticipate some temporal instability in situational motivations within courses. Research on the dynamic versus static nature of situational motivaitons is quite limited, however, and the published findings on the time dependency of situational motivations are mixed. Some authors report temporally dynamic motivational responses in college classrooms [27], [28], while others report "moderately stable" to "very stable" expression of motivational profiles over time [29]. Understanding the dyanamic nature of situational motivations may be especially important in active learning settings, where numerous social and environmental variables could impact motivations in ways not found in lecture settings.

For this study, we examine the connections among engineering students' situational motivations, basic needs satisfaction, and perceptions of the supportiveness of the learning climate, in a first-year, project-based course. We also examine the temporal stability of students' situational motivations during a short project module.

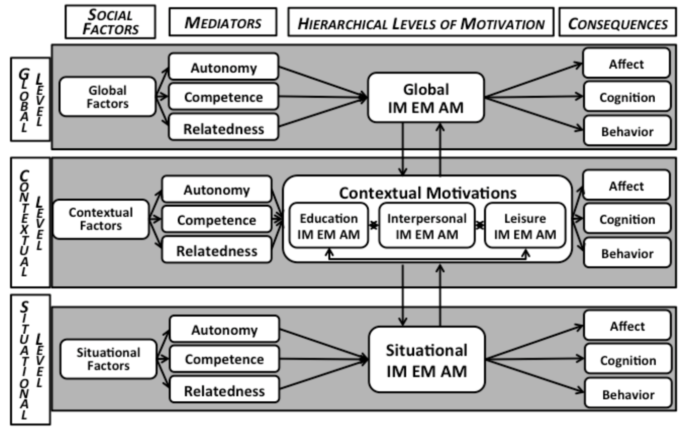

Fig. 2. The Hierarchical Model for Motivation, adapted from [16]. This study focuses on the situational social factors, mediators, and motivations.

II. Methods

A. Participants and Study Environment

Participants in the study are first-year college students enrolled in an introductory-level technical course at an undergraduate engineering school in the northeastern U.S. The participant group included 58 total students, with self-defined gender identities of: 30 men (52.6%), 23 women (39.7%), 2 non-binary (3.4%), and 3 unspecified or self-defined (5.1%).

The study setting is a large, integrated course block designed to build engineering students' quantitative analytical skills. The course integrates topics from mathematics, physics, and engineering, through hands-on assignments based on real-world problems and projects. The course is divided into several modules, each of which involves a task or problem setup, acquisition of background knowledge and skills, and application of knowledge in analytical and design challenges. The course has multiple professors as well as a team of undergraduate teaching assistants to offer aid on assignments. Larger projects are team-based, while background work is assessed individually, but with teamwork encouraged.

B. Data Collection and Analysis

Data were collected via web-based deployment of three questionnaires developed by SDT researchers. Students' perceived competence, autonomy, and relatedness in the course were measured using a modified version of the Basic Psychological Need Satisfaction in General Scale (BPNS-G) [1], [30], adapted for use in the college classroom in a manner similar to [31]. The BPNS is a 21-item, Likert-scaled (1=not at all true, 7=very true) questionnaire. Students' sense of autonomy support from their *instructors* was measured using the Learning Climate Questionnaire (LCQ), a 15-item, Likert-scaled (1=strongly disagree, 7=strongly agree) questionnaire [7]. Situational motivations were measured by the Situational Motivation Scale (SIMS), a 16-item, Likert-scaled instrument (1=corresponds not at all, 7=corresponds exactly) with good internal consistency and construct validity [32]. The SIMS measures four types of motivation along the self-determination continuum: amotivation, external regulation, identified regulation, and intrinsic motivation. We also calculated the self-determination index (SDI) [33], a single number that represents students' overall levels of autonomous versus controlled types of motivation, by weighting SIMS subscale means by their position on the self-determination continuum. SDI is calculated as: 2×(intrinsic motivation)+1×(identified regulation)–1×(external regulation)–2×(amotivation).

The study data were were collected over a one-week period in the course, during which students worked on a mobile robotics project with a series of tasks that culminated in autonomously navigating a small robot along a bridge in a parametric curve shape. This module was selected for its diverse range of activities, including theory, analysis, a quiz, and hands-on design. Data were collected at four times over the one-week project period, as follows:

- *T1: Module Introduction*. The BPNS, LCQ, and SIMS surveys were administered at the end of a class period that included a high-level introduction to robotics and basic technical concepts, readings, and partner exercises.
- *T2: Core Learning Assignment.* The SIMS survey was deployed at the start of a class session, just after students completed an assignment with theory-based technical work on parametric curves. The assignment contained reading as well problems to be completed by individual students.
- *T3: In-Class Activities.* In the same class session that began with the T2 survey, students completed an assignment to connect key concepts to a design challenge. The session included a short conceptual quiz, a discussion of the core learning assignment, and hands-on activities. The SIMS survey was administered at the end of this class period.
- *T4: Design Challenge.* The final assignment in the module was to complete the project design challenge, and deliver a short informal paper and a video of the robot completing the task. Students were given exercises as guides to completing the task, and the work was completed in pairs. The final SIMS survey was given at the beginning of the class period when the final assignment was due.

Descriptive statistics were compiled for all measures. Pearson correlations were calculated to examine associations among the study variables. T-tests were used to explore temporal changes and gender differences in motivation.

III. Results and Discussion

Descriptive statistics and correlations for all study variables are shown in Table I. Results indicate that students in the course express a high level of basic needs satisfaction, and a positive perception of their learning climate. On average, students adopt autonomous or self-determined motivations [29], with the value- or importance-based drive (identified regulation) as the strongest signal, followed closely by interest- and enjoyment-based drive (intrinsic motivation). Students report moderate levels of external regulation and low levels of amotivation. No significant gender differences were measured in any of the study variables.

Correlations among the study variables generally follow the trends predicted by theory [1] and reported in previous empirical studies [34]. Competence and autonomy are positively correlated with intrinsic motivation and identified regulation, and negatively correlated with external regulation and amotivation. Autonomy shows a particularly strong correlation with both intrinsic motivation (r = .382) and identified regulation (r = .499). Compared to competence and autonomy, relatedness is less strongly linked to motivation, but all of the relatedness-motivation correlations are in the expected directions. Students' positive perceptions of the learning climate are most strongly linked to identified regulation, with weaker yet significant correlations to intrinsic motivation (r = .337) and amotivation (r = -.332). Fig. 3 summarizes the strong relationships between positive motivations and basic needs satisfaction by plotting students' mean SDI value against competence (r = .517, $p < .01$), autonomy (r = .602, $p < .01$), and relatedness (r = .329, $p < .05$) at Time 1. Fig. 4 illustrates how the SDI relates to students' perceptions of the learning climate (r = .417, $p < .01$).

When viewed as distinct motivational responses over time (Fig. 5), the SIMS data illustrate the complex and dynamic nature of situational motivations. At T1, when the robotics project is first introduced, students show high levels of identified regulation and intrinsic motivation and lower levels of external regulation. From T1 to T2, however, students report a significant drop in intrinsic motivation (from M=4.96 to M=3.54), and increases in external regulation (M=3.65 to M=4.32) and amotivation (M=1.74 to M=2.47). T2 represents the start of a 3 hour class session, when students were asked to reflect on the activity assigned over the weekend: a lengthy problem set focused on developing a theoretical understanding

TABLE I. Intercorrelations between subscale variables, including competence, autonomy, and relatedness basic needs measures, learning climate perceptions, and situational motivation types (N=58).

Subscale	*M*	*SD*	1	2	3	4	5	6	7	8
1. Competence	5.20	0.84	--	.677**	.326*	.518**	.321*	.425**	-.370**	-.477**
2. Autonomy	4.92	0.86		--	.562**	.635**	.382**	.499**	-.471**	-.514**
3. Relatedness	5.60	0.68			--	.385**	0.213	.321*	-0.201	-.290*
4. Learning Climate Perceptions	5.48	0.77				--	.337*	.476**	-0.133	-.332*
5. Intrinsic Motivation	4.58	0.98					--	.502**	-.386**	-.288*
6. Identified Regulation	5.24	0.85						--	-.393**	-.387**
7. External Regulation	3.84	1.17							--	.499**
8. Amotivation	1.99	0.82								--

Notes. **Correlation is significant at the $p < 0.01$ level. * Correlation is significant at the $p < 0.05$ level.

of the concepts needed for the robotics project. It is tempting to explain the motivation dip as students' aversion to learning technical theory; but the high level of identified regulation sustained from T1 to T2 indicates that students are conscious of the value and importance of the learning activity.

Given the strong connections between students' positive motivations and their perceptions of competence and autonomy (Table I), we hypothesize that the T1 to T2 drop in motivation may be tied to a decline in competence or autonomy during the core learning assignment. Students begin the project at T1 with high levels of motivation and needs satisfaction. In the absence of support from faculty or course assistants, however, students who find the theory-based assignment too challenging may lose their sense of efficacy or competence, undermining intrinsic motivation, e.g., *I don't think I'm able to do this, therefore it's not fun and I don't want to do this*. Yet, since students must complete the assignment to be successful in the class, they may draw more heavily on external regulation to meet the course demands. Alternatively, students may perceive a loss of autonomy with the core learning assignment. The problem set nature of the assignment may decrease students' sense of control and volition, especially relative to open-ended project work. While they still find value of the assignment, students may find the experience less *intrinsically* interesting and enjoyable, and more *externally* demanding or controlling.

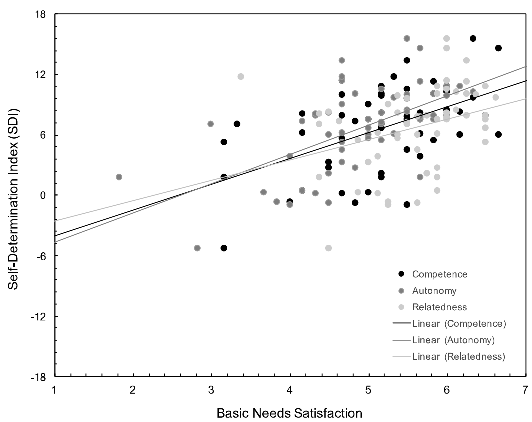

Fig. 3. Relationships between students' mean self-determination index (SDI) value, and satisfaction of basic psychological needs of competence, relatedness, and autonomy. N=56.

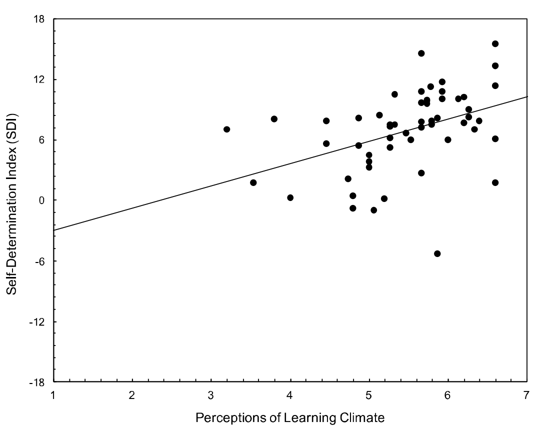

Fig. 4. Relationships between students' mean self-determination index (SDI) value and perceptions of the learning climate. N=55.

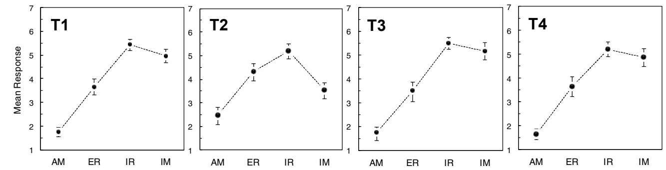

Fig. 5. Students' situational motivations throughout a one-week project. Note the significant decrease in intrinsic motivation (IM) and increase in external regulation (ER) from T1 to T2, followed by a return to higher IM and lower ER at T3. Error bars show 95% confidence intervals.

After the T2 dip, students' situational motivations rise sharply during the ensuing class period (T3), and remain high throughout the design challenge component of the project (T4). The increase in positive motivations from T2 to T3 could signal the effects of the positive learning climate, while the sustained positive motivations from T3 to T4 may indicate that students are better able to engage motivationally with applied design problems compared to theoretical assignments. Engagement in tasks that involve open-ended analysis and design may trigger stronger feelings of autonomy, and applying technical concepts through hands-on manipulation of physical artifacts (e.g., programming autonomous robots to navigate a complex path) may equip students with a sense of comptence in ways that problem sets cannot. Supportive faculty interactions may also play a role in students' positive motivations. The T2 motivational drop occurred over a weekend, when faculty were not available and support came primarily from peers. In contrast, the T4 assignment was completed during the week amidst ample faculty support.

IV. Summary and Future Directions

This pilot study of student motivations in an undergraduate course yielded several key findings. First, students express strong value- and interest-based motivations in project-oriented course activities. Second, basic psychological needs satisfaction and positive perceptions of the classroom climate correlate positively with autonomous motivations and negatively to controlled motivations. Third, a one-week project is sufficiently long to illustrate significant shifts in situational motivations. While additional work is necessary to fully understand and explain the measured motivational dynamics in the course, the findings from this pilot study highlight important, positive relationships among project-based learning activities, student perceptions of classroom climate, and student motivations that are consistent with SDT predictions and relevant to instructors seeking to create student-centered learning experiences for undergraduate engineers. Future work will involve additional activity- and course-level research on how specific pedagogies and other course design variables serve to satisfy or frustrate individuals' basic needs, and how needs satisfaction or frustration translates to learners' adoption of different motivations in engineering classrooms.

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References

[1] E. L. Deci and R. M. Ryan, "The "what" and "why" of goal pursuits: Human needs and the self-determination of behavior," Psychological Inquiry, vol. 11, pp. 227-268, 2000.

[2] P. R. Pintrich, The role of motivation in promoting and sustaining self-regulated learning," International Journal of Educational Research, vol. 31, pp. 459-470, 1999.

[3] G. Pelletier, M. S. Fortier, R. J. Vallerand, and N. M. Brière, "Associations among perceived autonomy support, forms of self-regulation, and persistence: A prospective study," Motivation and Emotion, vol. 25, no. 4, pp. 279-306, 2001

[4] C. F. Ratelle, F. Guay, R. J. Vallerand, S. Larose, and C. Senécal, "Autonomous, controlled, and amotivated types of academic motivation: A person-oriented analysis," Journal of Educational Psychology, vol. 99, no. 4, pp. 734-746, 2007.

[5] P. Pintrich and E. V. De Groot, "Motivational and self-regulated learning components of classroom academic performance," Journal of Educational Psychology, vol. 82, no. 1, pp. 33-40, 1990.

[6] M. Gagné, "The role of autonomy support and autonomy orientation in prosocial behavior engagement," Motivation and Emotion, vol. 27, no. 3, pp. 199-223, 2003.

[7] A. E. Black and E. L. Deci, "The effects of instructors' autonomy support and students' autonomous motivation on learning organic chemistry: A self-determination theory perspective," Science Education, vol. 84, no. 7, pp. 740-756, 2000.

[8] R. Pekrun, T. Goetz, and W. Titz, "Academic emotions in students' self-regulated learning and achievement: A program of qualitative and quantitative research," Contemporary Educational Psychologist, vol. 37, no. 2, pp. 91-105, 2002.

[9] R. Zhen, R. Liu, Y. Ding, J. Wang, Y. Liu, and L. Xu, "The mediating roles of academic self-efficacy and academic emotions in the relation between basic psychological needs satisfaction and learning engagement among Chinese adolescent students," Learn Individ Differ., vol. 54, pp. 210-216, 2017

[10] R. M. Ryan, and E. L. Deci, "Self-Determination Theory and the facilitation of intrinsic motivation," Social Development, and Well-Being," American Psychologist, vol. 55, no. 1, pp. 68-78, 2000.

[11] E. L. Deci, R. J. Vallerand, L. G. Pelletier, and R. M. Ryan, "Motivation and education: The self-determination perspective," Educational Psychologist, vol. 26 no. 3&4, pp. 325-346, 1991.

[12] M. S. Fortier, R. J. Vallerand, and F. Guay, "Academic motivation and school performance: Toward a Structural Model," Contemporary Educational Psychology, vol. 20, pp. 257-274, 1995

[13] E. L. Deci, R. Koestner, and R. M. Ryan, "A meta-analytic review of experiments examining the effects of extrinsic rewards on intrinsic motivation," Psychological Bulletin, vol. 125, no. 6, pp. 627-668, 1999.

[14] M. Vansteenkiste, E. Sierens, B. Soenens, K. Luyckx, and W. Lens, "Motivational profiles from a self-determination perspective: The quality of motivation matters," Journal of Educational Psychology, vol. 101, no. 3, pp. 671-688, 2009.

[15] M. Vansteenkiste, W. Lens, and E. L. Deci, "Intrinsic versus extrinsic goal contents in Self-Determination Theory: Another look at the quality of academic motivation," Educational Psychologist, vol. 41, no. 1, pp. 19-31, 2006.

[16] R. J. Vallerand, "Toward a hierarchical model of intrinsic and extrinsic motivation," In M. P. Zanna (Ed.), Advances in experimental social psychology, vol. 27, pp. 271–360. New York: Academic Press, 1997.

[17] R. J. Vallerand, "Deci and Ryan's self-determination theory: A view from the hierarchical model of intrinsic and extrinsic motivation," Psychological Inquiry, vol. 11, pp. 312-318, 2000.

[18] F. Guay, G. A. Mageau, and R. J. Vallerand, "On the hierarchical structure of self-determined motivation: A test of top-down, bottom-up, reciprocal, and horizontal effects," Personality and Social Psychology Bulletin, 29, 992-1004, 2003.

[19] C. F. Ratelle, M. W. Baldwin, and R. J. Vallerand, "On the cued activation of situational motivation," Journal of Experimental Social Psychology, vol. 41, pp. 482-487, 2005.

[20] K. A. Noels, R. Clement, and L. G. Pelletier, "Perceptions of teachers' communicative style and students' intrinsic and extrinsic motivation," The Modern Language Journal, vol. 83, no. 1, pp. 23-34, 1999.

[21] E. A. Patall, H. Cooper, and J. C. Robinson, "The effects of choice on intrinsic motivation and related outcomes: A meta-analysis of research findings," Psychological Bulletin, vol. 134, no. 2, pp. 270-300, 2008.

[22] J. Reeve, H. Jang, D. Carrell, S. Jeon, and J. Barch, "Enhancing students' engagement by increasing autonomy support," Motivation and Emotion, vol. 28, no. 2, pp. 147-169, 2004.

[23] T. Garcia and P. R. Pintrich, "The Effects of Autonomy on Motivation and Performance in the College Classroom," Contemporary Educational Psychology, vol. 21, pp. 477-486, 1996.

[24] J. León, J. L. Núñez, and J. Liew, "Self-determination and STEM education: Effects of autonomy, motivation, and self-regulated learning on high school math achievement," Learning and Individual Differences, vol. 43, pp. 156-163, 2015.

[25] H. Jang, "Teachers' intrinsic vs. extrinsic instructional goals predict their classroom motivating styles," Learning and Instruction, in press

[26] J. Reeve, "Why teachers adopt a controlling motivating style toward students and how they can become more autonomy supportive," Educational Psychologist, vol. 44, no. 3, pp. 159-175, 2009.

[27] A. Dillon and J. Stolk, "The Students are Unstable! Cluster analysis of motivation and early implications for educational research and practice," 2012 ASEE/IEEE Frontiers in Education, Seattle, WA, October 3-6, 2012.

[28] A. Dillon and J. D. Stolk, "Motivation-participation conflation: Investigating response bias in intra-semester longitudinal class surveys," 2014 ASEE/IEEE Frontiers in Education, Madrid, Spain, October 22-25, 2014.

[29] N. Gillet, A. J. S. Morin, and J. Reeve, "Stability, change, and implications of students' motivation profiles: A latent transition analysis," Contemporary Educational Psychology, vol. 51, pp. 222-239, 2017.

[30] M. Gagné, "The role of autonomy support and autonomy orientation in prosocial behavior engagement," Motivation and Emotion, vol. 27, pp. 199-223, 2003.

[31] M. A. Jenkins-Guarnieri, A. L. Vaughan, and S. L. Wright, "Development of a self-determination measure for college students: Validity evidence for the basic needs satisfaction at college scale," Meas Eval Couns Dev, vol. 48, no. 4, pp. 266-284, 2015.

[32] F. Guay, R. J. Vallerand, and C. Blanchard, "On the assessment of situational intrinsic and extrinsic motivation: The Situational Motivation Scale (SIMS)," Motivation and Emotion, vol. 24, no. 3, pp. 175-213, 2000.

[33] R. M. Ryan and J. P. Connell, "Perceived locus of causality and internalization: Examining reasons for acting in two domains," Journal of Personality and Social Psychology, vol. 57, no. 5, pp. 749-761, 1989.

[34] W. C. Liu, C. K. J. Wang, O. S. Tan, C. Koh, and J. Ee, "A self-determination approach to understanding students' motivation in project work," Learning and Individual Differences, vol. 19, pp. 139-145, 2009.